

CLAIMS

What is claimed is:

1. A method of servicing a wellbore, comprising: using a thermally-controlled tool in the wellbore.
2. The method of claim 1, wherein the tool comprises a thermally-controlled valve.
3. The method of claim 2, wherein the thermally-controlled valve is used to control the flow of material into, through, or from the wellbore.
4. The method of claim 3, wherein the material comprises hydrocarbons, water, steam, surfactants, polymers, or combinations thereof.
5. The method of claim 3, wherein the wellbore is arranged in an SAGD configuration, a multilateral wellbore configuration, or a common wellbore configuration.
6. The method of claim 2, wherein a plurality of thermally-controlled valves are arranged in the wellbore to achieve a substantially uniform temperature profile in a portion of the wellbore by controlling the injection of steam into the wellbore.
7. The method of claim 6, wherein the injection of the steam heats oil in an adjacent subterranean zone, thereby decreasing a viscosity of the oil.
8. The method of claim 2, wherein a plurality of thermally-controlled valves are arranged in a production conduit disposed in the wellbore to control the recovery of material from the wellbore.
9. The method of claim 8, wherein the thermally-controlled valves restrict the flow of steam out of the wellbore.
10. The method of claim 2, wherein the thermally-controlled valve comprises a balanced pressure thermostatic valve, a bimetallic valve, a bi-metal reed valve, a bi-metal sliding valve, a

concentric sleeve valve, a variable-orifice radial valve, a variable-orifice radial valve, or combinations thereof.

11. The method of claim 6, wherein the thermally-controlled valve is connected to a steam line for injecting the steam into the wellbore.

12. The method of claim 3, wherein the thermally-controlled valve comprises a valve body comprising an injection port for allowing passage of the material into or out of the wellbore.

13. The method of claim 12, wherein the thermally-controlled valve further comprises an opening/closing mechanism for regulating flow through the injection port in response to changes in temperature.

14. The method of claim 13, wherein the opening/closing mechanism is located in a side pocket of the valve.

15. The method of claim 13, wherein the opening/closing mechanism comprises a material capable of expanding and contracting to regulate flow through the injection port in response to changes in temperature.

16. The method of claim 13, wherein the opening/closing mechanism comprises at least one expansion chamber capable of expanding and contracting in response to changes in temperature.

17. The method of claim 16, wherein the opening/closing mechanism comprises a slidable sleeve near the expansion chamber, the slidable sleeve being capable of moving in response to the expansion and contraction of the expansion chamber.

18. The method of claim 17, wherein the opening/closing mechanism comprises an expandable member near an end of the slidable sleeve opposite from the expansion chamber, and wherein the slidable sleeve is capable of moving in response to the expansion and contraction of the expandable member.

19. The method of claim 18, wherein the expandable member comprises a spring or a piston.
20. The method of claim 18, wherein a hole in the slidable sleeve becomes mis-aligned with the injection port when a detected temperature becomes about less than or equal to a set point temperature, thereby reducing flow through the injection port.
21. The method of claim 18, wherein a hole in the slidable sleeve becomes aligned with the injection port when a detected temperature becomes about equal to a set point temperature, thereby increasing flow through the injection port.
22. The method of claim 18, wherein a hole in the slidable sleeve becomes mis-aligned with the injection port when a detected temperature becomes about greater than or equal to a set point temperature, thereby reducing flow through the injection port.
23. The method of claim 18, wherein the valve body comprises left and right return ports for allowing passage of the material into or out of the wellbore.
24. The method of claim 23, wherein the left return port is laterally offset from a left side of the injection port and the right return port is laterally offset from the right side of the injection port.
25. The method of claim 24, wherein a hole in the slidable sleeve becomes aligned with the left return port and mis-aligned with the injection port and the right return port when a detected temperature becomes about less than or equal to a set point temperature.
26. The method of claim 24, wherein a hole in the slidable sleeve becomes aligned with the injection port and mis-aligned with the left and right return ports when a detected temperature becomes about equal to a set point temperature.

27. The method of claim 24, wherein a hole in the slidable sleeve becomes aligned with the right return port and mis-aligned with the injection port and the left return port when a detected temperature becomes about greater than or equal to a set point temperature.
28. The method of claim 17, further comprising adjusting a nut of the thermally-controlled valve to cause the slidable sleeve to move and thereby adjust the regulation of flow through the injection port.
29. The method of claim 2, wherein the thermally-controlled valve comprises a brain for regulating the flow of material through the valve and a side pocket for holding the brain.
30. The method of claim 29, wherein a tool is used to position the brain in the side pocket.
31. The method of claim 30, wherein the tool is used to retrieve the brain from the side pocket.
32. A thermally-controlled valve for injecting material into a wellbore, comprising:
- (a) a valve body comprising an injection port for allowing the material to flow into or out of the wellbore; and
 - (b) an opening/closing mechanism for regulating flow through the injection port in response to a change in temperature.
33. The thermally-controlled valve of claim 32, wherein the opening/closing mechanism is located in a side pocket of the valve.
34. The thermally-controlled valve of claim 32, further comprising connectors for coupling the valve body to a downhole conduit or tool.
35. The thermally-controlled valve of claim 32, wherein the valve body is threaded to couple with a downhole conduit or tool.

36. The thermally-controlled valve of claim 34, wherein the downhole conduit comprises a steam delivery conduit, an oil production conduit, or combinations thereof.

37. The thermally-controlled valve of claim 32, wherein the opening/closing mechanism comprises a material capable of expanding and contracting to regulate flow through the injection port in response to changes in temperature.

38. The thermally-controlled valve of claim 32, wherein the opening/closing mechanism comprises at least one expansion chamber, the expansion chamber being capable of expanding and contracting in response to changes in temperature.

39. The thermally-controlled valve of claim 38, wherein the opening/closing mechanism comprises a slidable sleeve near the expansion chamber, the slidable sleeve being capable of moving in response to the expansion and contraction of the expansion chamber.

40. The thermally-controlled valve of claim 39, wherein the opening/closing mechanism comprises an expandable member near an end of the slidable sleeve opposite from the expansion chamber, the slidable sleeve being capable of moving in response to the expansion and contraction of the expandable member.

41. The thermally-controlled valve of claim 40, wherein the expandable member comprises a spring or a piston.

42. The thermally-controlled valve of claim 40, wherein the slidable sleeve comprises a hole for controlling flow through the injection port by alignment or mis-alignment with the injection port.

43. The thermally-controlled valve of claim 32, wherein the opening/closing mechanism is adapted to become aligned with the injection port when a temperature of the material becomes about equal to a set point temperature.

44. The thermally-controlled valve of claim 32, wherein the slidable sleeve is adapted to become mis-aligned with the injection port when a temperature of the material becomes about less than or equal to a first set point temperature or about greater than or equal to a second set point temperature.

45. The thermally-controlled valve of claim 32, wherein the valve body comprises left and right return ports for allowing material to flow into a return line for conveying the material from the wellbore.

46. The thermally-controlled valve of claim 45, wherein the material comprises condensate.

47. The thermally-controlled valve of claim 45, wherein the left return port is laterally offset from a left side of the injection port and the right return port is laterally offset from a right side of the injection port.

48. The thermally-controlled valve of claim 47, wherein the slidable sleeve comprises a hole for controlling flow through the injection port and the right and left return ports by alignment or mis-alignment therewith.

49. The thermally-controlled valve of claim 47, wherein the opening/closing mechanism is adapted to become aligned with the left return port and mis-aligned with the injection port and the right return port when a temperature of the material becomes about less than or equal to a set point temperature.

50. The thermally-controlled valve of claim 47, wherein the opening/closing mechanism is adapted to become aligned with the injection port and mis-aligned with the right and left return ports when a temperature of the material becomes about equal to a set point temperature.

51. The thermally-controlled valve of claim 47, wherein the opening/closing mechanism is adapted to become aligned with the right return port and mis-aligned with the left return port and

the injection port when a temperature of the material becomes about greater than or equal to a set point temperature.

52. The thermally-controlled valve of claim 32, comprising a brain for regulating the flow of material through the valve and a side pocket for holding the brain.

53. The thermally-controlled valve of claim 32, wherein the brain is capable of being removed from the side pocket.

54. The thermally-controlled valve of claim 39, comprising a nut that is capable of being adjusted to cause the slidable sleeve to move and thereby adjust the regulation of flow through the injection port.

55. A system for regulating the flow of material in a wellbore, comprising:

(a) a downhole conduit for conveying the material into, through, or out of the wellbore; and

(b) at least one thermally-controlled valve for regulating the flow of the material, the thermally-controlled valve being connected to the conduit.

56. The system of claim 55, wherein the material comprises hydrocarbons, water, steam, surfactants, polymers, or combinations thereof.

57. The system of claim 55, wherein the downhole conduit comprises a steam delivery conduit, an oil production conduit, or combinations thereof.

58. The system of claim 55, wherein the wellbore is arranged in an SAGD configuration, a multilateral wellbore configuration, or a common wellbore configuration.

59. The system of claim 55, wherein the thermally-controlled valve comprises a balanced pressure thermostatic valve, a bimetallic valve, a bi-metal reed valve, a bi-metal sliding valve, a

concentric sleeve valve, a variable-orifice radial valve, and a variable-orifice radial valve, or combinations thereof.

60. The system of claim 55, wherein the thermally-controlled valve comprises a valve body comprising an injection port for allowing the material to flow into or out of the wellbore.

61. The system of claim 60, wherein the thermally-controlled valve further comprises an opening/closing mechanism for regulating flow through the injection port in response to changes in temperature.

62. The system of claim 61, wherein the opening/closing mechanism is located in a side pocket of the valve.

63. The system of claim 61, further comprising a return conduit for returning material from the wellbore, the thermally-controlled valve being connected to the return conduit.

64. The system of claim 63, wherein the material comprises condensate.

65. The system of claim 63, wherein the valve body further comprises left and right return ports for allowing the fluid to flow into the return conduit.

66. The system of claim 65, wherein the left return port is laterally offset from a left side of the injection port and the right return port is laterally offset from a right side of the injection port.

67. The system of claim 66, wherein the opening/closing mechanism is adapted to become aligned with the left return port and become mis-aligned with the injection port and the right return port when a temperature of the material becomes about less than or equal to a set point temperature.

68. The system of claim 66, wherein the opening/closing mechanism is adapted to become aligned with the injection port and become mis-aligned with the right and left return ports when a temperature of the material becomes about equal to a set point temperature.

69. The system of claim 66, wherein the opening/closing mechanism is adapted to become aligned with the right return port and become mis-aligned with the left return port and the injection port when a temperature of the material becomes about greater than or equal to a set point temperature.
70. The system of claim 55, wherein the thermally-controlled valve comprises a brain for regulating the flow of material through the valve and a side pocket for holding the brain.
71. The system of claim 70, wherein the brain is capable of being removed from the side pocket.
72. A thermally-controlled downhole tool.
73. The tool of claim 72, comprising a control element responsive to a change in temperature.
74. The tool of claim 73, wherein the control element controls the flow of fluid into, out of, or through a wellbore.
75. The tool of claim 73, wherein the control element controls a power source.
76. The tool of claim 72, wherein the control element further comprises a temperature sensor coupled to an actuator or an amplifier.
77. The tool of claim 76, wherein the actuator is mechanically driven or produces a mechanical output.
78. The tool of claim 76, wherein the actuator is electrically driven or produces an electrical output.
79. The tool of claim 76, wherein the actuator is hydraulically driven or produces a hydraulic output.
80. The tool of claim 76, wherein the actuator is optically driven or produces an optical output.

81. The tool of claim 76, wherein the control element is capable of sending a signal to the actuator or the amplifier.
82. The tool of claim 81, further comprising an electrical, hydraulic, or optical line for transmitting the signal.
83. The tool of claim 76, wherein the amplifier comprises a servomechanism.
84. The tool of claim 73, wherein the control element comprises a mechanical element actuated by changes in temperature.
85. The tool of claim 84, wherein the mechanical element comprises a thermally expandable material.
86. The tool of claim 85, wherein the thermally expandable material comprises a polymer, a composite material, a hydrocarbon-derived material, an organic material, an inorganic material, a metal, a bi-metal, or combinations thereof.
87. The tool of claim 85, wherein the polymer comprises PEEK.
88. The tool of claim 85, wherein the composite comprises PEEK combined with glass fibers.
89. The tool of claim 84, wherein the mechanical element comprises one or more thermal expansion chambers.
90. The tool of claim 89, wherein the thermal expansion chamber is filled with an expanding and contracting material.
91. The tool of claim 72, comprising a thermally-controlled valve.
92. The tool of claim 91, wherein the thermally-controlled valve is capable of controlling the flow of material downhole.

93. The tool of claim 91, wherein the thermally-controlled valve is actuated between an open position, a closed position and intermediate positions therebetween.
94. A method of operating a downhole tool, comprising: thermally-controlling the tool.
95. The method of claim 94, wherein the thermostatic-control further comprises sensing a temperature and controlling the tool in response to the sensed temperature.
96. The method of claim 95, wherein the flow of fluid into, out of, or through a wellbore or a conduit is controlled.
97. The method of claim 95, further comprising actuating an element of the tool in response to the sensed temperature.
98. The method of claim 97, wherein the element is actuated using mechanical means, electrical means, hydraulic means, optical means, or combinations thereof.
99. The method of claim 94, wherein the thermostatic-control is implemented via thermal expansion of a mechanical element of the tool.
100. The tool of claim 99, wherein the mechanical element comprises a thermally expandable material.
101. The tool of claim 100, wherein the thermally expandable material comprises a polymer, a metal, a bi-metal, a composite, a hydrocarbon-derived material, an organic material, an inorganic material, or combinations thereof.
102. The tool of claim 100, wherein the mechanical element comprises one or more thermal expansion chambers.
103. The tool of claim 102, wherein the thermal expansion chamber is filled with an expanding and contracting fluid or solid.
104. The method of claim 94, wherein the tool comprises a thermally-controlled valve.

105. The method of claim 104, wherein the thermally-controlled valve is capable of controlling the flow of material downhole.

106. The tool of claim 104, wherein the thermally-controlled valve is actuated between an open position, a closed position, and intermediate positions therebetween.